




## Climate Change, the Indoor Environment, and Health

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# Summary

Climate change<sup>1</sup> poses “a significant long-term challenge for the United States” (NRC, 2010b). Its potential effects on public health have been addressed in major research efforts conducted under the auspices of the federal US Global Change Research Program and the National Center for Environmental Health, the congressionally mandated National Academy of Sciences *America’s Climate Choices* study initiative, and the Intergovernmental Panel on Climate Change of the United Nations Environment Programme and the World Meteorological Organization. A search of the US National Library of Medicine’s *PubMed* database in late February 2011 yielded nearly 1,500 papers on the topics of climate change or global warming and health.

In all that work, one issue has been given relatively little attention: the effect of climate-change-induced alterations in the indoor environment on occupant health. At first impression, the lack of attention might seem reasonable. Buildings shelter occupants from the outdoors. A deeper examination, though, provides reasons to be concerned. People spend the vast majority of their time in indoor environments and will thus experience many of the effects of climate change indoors. The outdoor environment permeates indoors in all but maximum-containment laboratory conditions. A building that was tightly sealed as a response to adverse outdoor conditions or because of efforts to reduce energy use might protect occupants from one set of problems but would increase their exposure to another: such buildings tend to have decreased ventilation rates, higher concentrations of indoor-emitted pollutants, and more occupants reporting health problems.

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<sup>1</sup> This report uses the term *climate* to refer to prevailing outdoor environmental conditions—temperature, humidity, wind, precipitation, sea level, and other phenomena—and *climate change* to refer to modifications in those outdoor conditions that occur over an extended period of time.

Against that backdrop, the US Environmental Protection Agency (EPA) asked the Institute of Medicine (IOM) to convene an expert committee to summarize the current state of scientific understanding with respect to the effects of climate change on indoor air and public health. It provided three examples of key questions to address:

- What are the likely impacts of climate change in the United States on human exposure to chemical and biological contaminants inside buildings, and what are the likely public health consequences?
- What are the likely impacts of climate change on moisture and dampness conditions in buildings, and what are the likely public health consequences?
- What are the priority issues for action?

This report, prepared by the Committee on the Effect of Climate Change on Indoor Air Quality and Environmental Health, provides a response to that charge.

## **FRAMEWORK AND ORGANIZATION**

The first three chapters of the report present introductory and background materials. Subsequent chapters address five major issues related to potential alterations in indoor environmental quality induced by climate change:

- The chemical, organic, and particulate pollutants that can be found in the indoor environment—including infiltrates from the outdoors and pollutants resulting from indoor combustion and other indoor emission sources—and the possible health effects of exposure to them (Chapter 4).
- The health implications of damp indoor spaces, including the effects of exposure to mold and bacteria and their components and to outgassing from the degradation of wet building materials (Chapter 5).
- How various infectious agents, insects, and arthropods that can be found indoors may be affected by climate change (Chapter 6).
- The physiologic, economic and social factors that influence vulnerability to prolonged exposure to temperature and humidity extremes and the resources available to mitigate such conditions, including air conditioning and other active and passive means to control the indoor thermal environment (Chapter 7).
- How human health is influenced by building energy use, emissions from building materials, weatherization, and ventilation and possible means to ameliorate adverse effects (Chapter 8).

The sections below are a synopsis of the committee's major findings, conclusions and recommendations.

## REPORT SYNOPSIS

### Why the Effect of Climate Change on the Indoor Environment and Health Is an Issue

Indoor environmental conditions exert considerable influence on health, learning, and productivity. Poor environmental conditions and indoor contaminants are estimated to cost the US economy tens of billions of dollars a year in exacerbation of illnesses, allergic symptoms, and lost productivity (Fisk and Rosenfeld 1997).

Climate change has the potential to affect the indoor environment. There is a large literature on how the indoor environment influences occupant health and how the external environment influences the indoor environment under different climate conditions. Research on the possible effects of climate change on human health is also emerging. However, the intersection of those bodies of research—the fraction specifically on the effects of climate change on human health in the indoor environment—is small. Such studies are complicated by the fact that the effects of climate change on indoor environmental quality are region-dependent and vary with the age and condition of the regionally dependent built environment.

Multiple parts of government and the private sector have a stake in issues of climate change, indoor environmental quality, and public health, but no one body has lead responsibility. As a result, there is a lack of leadership in identifying potential hazards, formulating solutions, and setting research and policy priorities.

### Elements of Climate-Change Research Relevant to the Indoor Environment and Health

A 2010 National Academies report concluded that climate change “poses significant risks for a broad range of human and natural systems” (NRC, 2010a). Measurements indicate that the first decade of the 21st century was warmer than the first decade of the 20th century. In the United States, hot days, hot nights, and heat waves have become more frequent in recent decades. On an urban scale, the heat-island effect contributes to local temperature increases. Rainfall measurements show that extreme events are increasing, moist regions are becoming wetter, and semiarid regions are becoming drier. Projections suggest that those trends will continue and may intensify.

### Indoor Air Quality

Three classes of factors have important influences on the indoor concentration of a pollutant: the pollutant’s source properties and other attributes, building characteristics, and human behavior. Climate change can affect these factors in numerous ways. Changes in the outdoor concentrations of a pollutant due to alterations in atmospheric chemistry or other factors such as atmospheric circulation will affect indoor concentrations. Mitigation measures to reduce energy use in buildings could lead to systematically lower ventilation rates that would cause higher concentrations and exposures to secondhand smoke and other indoor pollutants. Increased use of air conditioning, an expected adaptation measure, could exacerbate emissions of greenhouse

gases and, if accompanied by reduced ventilation rates, increase the concentrations of pollutants emitted from indoor sources. The potential for poisoning from exposure to carbon monoxide emitted from portable electricity generators may increase if peak electricity demand due to heat waves or extreme weather events leads to power outages.

Combustion is a major source of both outdoor and indoor air pollution and is arguably the most important class of indoor air pollutants with respect to health risks. Use of solid-fuel stoves, which are much more common in less developed countries, is associated with demonstrable adverse effects. Switching to lower-emissions units would yield substantial health benefits and decreases in the production of greenhouse gases.

### **Dampness, Moisture, and Flooding**

Studies reviewed in the 2004 IOM report *Damp Indoor Spaces and Health* and confirmed by later research indicates that

- Excessive indoor dampness is a determinant of the presence or source strength of several potentially problematic exposures. Damp indoor environments favor house-dust mites and the growth of mold and other microbial agents, standing water supports cockroach and rodent infestations, and excessive moisture may initiate or increase chemical emissions from building materials and furnishings.
- Damp indoor environments are associated with the initiation or exacerbation of a number of respiratory ailments.

Extreme weather conditions associated with climate change may lead to breakdowns in building envelopes followed by sudden infiltration of water into indoor spaces. Dampness problems and water intrusion create conditions favorable to the growth of fungi and bacteria and may cause building materials to decay or corrode; this can lead to off-gassing of chemicals. Well-designed and properly operating heating, ventilation, and air-conditioning (HVAC) systems can ameliorate humid conditions, but poorly designed or maintained systems may introduce moisture and create condensation on indoor surfaces. Mold-growth prevention and remediation activities may also introduce fungicides and other agents into the indoor environment, which can lead to adverse exposures of occupants.

### **Infectious Agents and Pests**

Weather fluctuations and seasonal to annual climate variability influence the incidence of many infectious diseases. Climate change may affect the evolution and emergence of infectious diseases by, for example, affecting the geographic range of disease vectors. However, relationships between climate and infectious disease often depend heavily on local conditions and may be influenced by indoor characteristics such as air conditioning, which affects indoor temperature and humidity, so it is difficult to draw general conclusions.

The ecologic niches for pests will change in response to climate change. Although decreases in populations in some locations may lower the incidence of allergic reactions to particular pests,

the overall incidence of allergic disease may not go down, because those with a predisposition to allergies may become sensitized to other regional airborne allergens.

Climate change may also lead to shifting patterns of indoor exposure to pesticides as occupants and building owners respond to infestations of pests like termites whose geographic ranges have changed.

### **Thermal Stress**

Extreme heat and cold have several well-documented adverse health effects. The elderly, those in poor health, the poor, and those who live in cities are more vulnerable to both exposure to temperature extremes and the effects of exposure. Those populations experience excessive temperatures almost exclusively in indoor environments. Air conditioning provides protection from heat but is associated with higher reported prevalences of some ailments, perhaps because of contaminants in HVAC systems. It also protects against exposure to high concentrations of outdoor pollutants. Temperate indoor conditions are associated with higher work productivity than colder or warmer environments.

Available information on the effects of climate change on building energy use and occupant health indicates that changing conditions may have the following effects:

- Buildings that are currently ventilated naturally will need to use some form of air conditioning.
- Buildings that have air conditioning will need to use it more often, reducing natural ventilation.
- People in buildings that do not have air conditioning will be exposed to extreme heat conditions more often.

Several technologies and building-design and -siting approaches can provide control of the indoor environment with lower energy costs and greater health benefits than systems typically in use today. No matter which approach is used to maintain safe indoor environmental conditions, it is important to ensure that the conditions are sustained when failures in building systems or power outages disable mechanical ventilation—something that may happen more often if climate change leads to more instances of extreme weather conditions or unsustainable loads on the electric grid.

### **Building Ventilation, Weatherization, and Energy Use**

Research indicates that poor ventilation in homes, offices, and schools is associated with occupant health problems or lower productivity. However, the information base is limited, and studies in hot and humid climates are lacking. Climate change may make ventilation problems more common or more severe in the future by stimulating the implementation of energy-efficiency (weatherization) measures that limit the exchange of indoor air with outdoor air.

Introduction of new materials and weatherization techniques may lead to unexpected exposures and health risks. Energy-efficiency programs should therefore incorporate tracking

mechanisms to identify problems with indoor environmental quality as they arise and to gather information on the effectiveness of solutions as they are developed and implemented.

Government and consensus organizations are beginning to recognize the importance of this issue and have established or are establishing voluntary guidelines and codes that account for the links between energy efficiency, indoor environmental quality, ventilation, and occupant health and productivity. Problems will persist, however, unless the weatherization workforce is trained to recognize and avoid problems with indoor environmental quality, the efficacy of guidelines and codes is validated, and they are widely implemented.

## RESULTS

While there is substantial scientific literature on the effects of outdoor environmental conditions on the indoors, of indoor environmental conditions on health, of climate change on health, of climate change on buildings, and of buildings on climate change, there is almost no literature on the intersection of climate change, indoor environmental quality, and occupant health—and much of what little literature there is summarizes information on one or more of the above categories rather than offering original contributions. The committee was thus required to approach its task by reviewing the available information on components of the climate-change–IEQ–occupant-health nexus and deriving its results on the basis of a synthesis of that information.

The observations and recommendations are based on the committee’s review of the scientific literature and on general conclusions reached in previous National Academies reports on climate change and literature those reports found to be authoritative. They do not depend on any particular model of future climatic conditions. The literature on indoor environmental quality and health is rich and unequivocal: indoor environmental conditions have a great influence on human health, and adverse conditions harm occupant well-being. Altered climatic conditions will not necessarily introduce new risks for building occupants but may make existing indoor environmental problems more widespread and more severe and thus increase the urgency with which prevention and interventions must be pursued.

The concluding chapter of the report (9) explicates the key findings, guiding principles, and priority issues for action and recommendations presented below.

### Key Findings

Three key findings derived from the committee’s literature review underlie its conclusion that alterations in indoor environmental quality induced by climate change are an important public-health problem that deserves attention and action.

**Poor indoor environmental quality is creating health problems today and impairs the ability of occupants to work and learn.**

**There is inadequate evidence to determine whether an association exists between climate-change–induced alterations in the indoor environment and any specific adverse health outcomes. However, available research indicates that climate change may make existing indoor environmental problems and introduce new problems by**

- **Altering the frequency or severity of adverse outdoor conditions that affect the indoor environment.**
- **Creating outdoor conditions that are more hospitable to pests, infectious agents, and disease vectors that can penetrate the indoor environment.**
- **Leading to mitigation or adaptation measures and changes in occupant behavior that cause or exacerbate harmful indoor environmental conditions.**

**Opportunities exist to improve public health while mitigating or adapting to alterations in indoor environmental quality induced by climate change.**

### **Guiding Principles**

The mission of public health is to “[fulfill] society’s interest in assuring conditions in which people can be healthy”, and its aim is “to generate organized community effort to address the public interest in health by applying scientific and technical knowledge to prevent disease and promote health” (IOM, 1988). The committee took a public-health approach in formulating its recommendations for reducing the health effects of alterations in IEQ induced by climate change, which can be summarized in three guiding principles:

**Prioritize consideration of health effects into research, policy, programs, and regulatory agendas that address climate change and buildings.**

As the country moves toward a future where climate change will spur the need for increased action to lower buildings’ energy demands and increase their resistance to adverse outdoor conditions, it is vital that public health be put in the forefront of the criteria taken into account in making decisions on issues that affect indoor environmental quality.

**Make the prevention of adverse exposures a primary goal when designing and implementing climate change adaptation and mitigation strategies.**

Prevention is a foundation principle in public health. Indoor environments already present myriad opportunities for adverse exposures. Common sense suggests that eliminating or lessening those exposures and limiting the introduction of new agents should be the first consideration when responding to potential problems.

**Collect data to make better-informed decisions in the future.**

A central aim of public-health professionals is “to maximize the influence of accurate data and professional judgment on decision-making—to make decisions as comprehensive and objective as possible” (IOM, 1998). Collecting data that support assessments of the effects of climate change on the indoor environment and health and data on the effects of mitigation and



adaptation measures on health will allow future policy to be set in a more informed manner and help to identify misguided or inefficient approaches so that they can be corrected.

### **Priority Issues For Action and Recommendations**

Chapters 4–8 offer several observations regarding how climate change may affect indoor air quality; dampness, moisture, and flooding; infectious agents and pests; exposure to thermal stress; and building ventilation, weatherization, and energy use. The items below constitute a distillation of the committee's thoughts on how their findings and conclusions should be operationalized.

**The committee recommends that the Environmental Protection Agency undertake the following actions.**

**The Environmental Protection Agency should work with such agencies as the Centers for Disease Control and Prevention to assist state, territorial, and local health and emergency-management agencies in efforts to initiate or expand programs to identify populations at risk for health problems resulting from alterations in indoor environmental quality induced by climate change and to implement measures to prevent or lessen the problems.**

EPA is a source of expertise on a number of issues related to the indoor environment and health. The Centers for Disease Control and Prevention (CDC)—which has the lead federal role in monitoring health, detecting and investigating health problems, and developing and implementing responses—already works with EPA on topics of common interest, such as the health effects of dampness and mold. Such cooperation will become more important if extreme weather events become more frequent or severe. EPA's knowledge in such fields as weatherization will be of great use in anticipating which future populations may be at risk and in developing solutions. The committee recommends that interagency collaboration between EPA and CDC expand into emerging issues of climate change and indoor environmental quality. Populations whose health, economic situation, or social circumstances make them more vulnerable to adverse consequences will require special attention in this regard.

**The Environmental Protection Agency and other federal agencies should join to develop or refine protocols and testing standards for evaluating emissions from materials, furnishings, and appliances used in buildings and to promote their use by standards-setting organizations and in the marketplace. Standards should include consideration of emissions over the operational life of products and the effects of changes in indoor temperature, dampness, and pests.**

Prevention of adverse exposures to materials in the indoor environment and those introduced as a part of weatherization and other climate-change mitigation activities should have high priority, but relatively little information is available. Organizations and government entities in the United States and other countries are pursuing and promoting testing protocols, but these efforts are fragmentary. Facilitating the development of uniform test standards not only will help builders and occupants make more informed decisions about which materials, furnishings, and appliances to use in buildings but will simplify compliance for manufacturers. The committee

recommends that EPA pursue expanded and coordinated action with other federal agencies, which will help to ensure that protocols are comprehensive and will promote their acceptance.

**The Environmental Protection Agency should expand and accelerate its efforts to ensure that indoor environmental quality is protected and enhanced in building-weatherization efforts by facilitating research to identify circumstances in which mitigation and adaptation measures may cause or exacerbate adverse exposures; by reviewing and, where appropriate, changing weatherization guidance to prevent these exposures; and by establishing criteria for the certification of weatherization contractors in health-protective procedures.**

One of the primary points made in this report is that buildings are complex systems whose siting, design, and operation interact in ways that are not necessarily easy to predict. EPA and the Department of Energy (DOE) are already cooperating on protocols for home energy-conservation upgrades that were in draft form when the committee completed its report. Such recognition of health effects on both occupants and persons performing weatherization work is welcome. The committee recommends that it be followed, however, by surveillance activities that evaluate whether guidance is achieving its health-protective objectives and recommends that a mechanism be put into place to revise guidance on the basis of evaluation. It also recommends certification of weatherization contractors in health-protective procedures, which would allow consumers to make better-informed decisions on whom they choose to perform work and give governments and utilities guidance on potential service providers.

**The Environmental Protection Agency in coordination with the Department of Energy, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, and building-code organizations should facilitate the revision and adoption of building codes that are regionally appropriate with respect to climate-change projections and that promote the health and productivity of occupants.**

EPA works in cooperation with the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), a professional organization, in developing guidelines for indoor air quality and ventilation. DOE works with ASHRAE and other stakeholders on building energy codes. ASHRAE standards for building ventilation and thermal comfort are often incorporated in building codes. The committee recommends that those cooperative efforts on codes be extended to encompass climate-change issues. Most residential and commercial buildings have useful lifetimes that are measured in decades. Promoting research on and development and adoption of regionally appropriate building codes that account for the possibility of future climatic conditions not only will protect the well-being of occupants but could produce economic benefits in the form of longer building lives, lower building insurance fees, and avoided retrofitting costs.

**The Environmental Protection Agency and other public agencies and private organizations should join to develop model standards for ventilation in residential buildings and to foster updated standards for commercial buildings and schools. The standards should**

- **Be based on health-related criteria.**
- **Account for the effects of weatherization and of other climate-change-related retrofits of existing buildings.**
- **Provide design and operation criteria for mechanical ventilation systems in new construction.**
- **Include consideration of ventilation system hygiene and ventilation effectiveness.**
- **Address how to maintain proper ventilation throughout the life of the system.**
- **Contain “fail-safe” provisions that allow for sufficient air exchange with the outdoors to sustain occupant well-being in the event of ventilation-system breakdown or an extended power outage.**
- **Achieve the objectives mentioned above in an energy- and cost-efficient manner.**

Current ventilation standards are not based on maintaining the health and productivity of occupants and do not account for the potential effects of climate change on building design and operation and on occupant behavior. The committee believes that action should be taken to address this. New ventilation standards should take into account all the considerations listed above. The committee recommends that EPA foster the development and implementation of standards in cooperation with other stakeholders.

**The Environmental Protection Agency and other federal agencies should put into place a public-health surveillance system that uses existing environment and health survey instruments to gather information on how outdoor conditions, building characteristics, and indoor environmental conditions are affecting occupant health and on how these change over time.**

Lack of general population information on the influence of buildings on occupant health hampers the setting of priorities and the development of effective interventions. The committee believes that it is important to start collecting such data. The ideal surveillance system for assessing how climate change affects indoor environment exposures and related health effects would collect data from across the nation and have this clear focus. However, there are substantial logistical hurdles in mounting such an effort, and its high cost may not be tenable under current federal budget circumstances. The committee therefore recommends that EPA cooperate with its collaborating agencies to identify means for adapting existing environment and health survey instruments to meet the need. It believes that, although challenges exist, it is possible to identify ways to modify and add to existing instruments such as the National Health and Nutrition Examination Survey (NHANES) and Behavioral Risk Factor Surveillance System (BRFSS) to generate useful data and facilitate combining of databases to perform novel analyses.

**The Environmental Protection Agency should exercise a strong level of commitment to educate the public on issues of climate change, the indoor environment, and health. Its efforts should**

- **Include materials tailored to those involved in the design, construction, operation, and maintenance of buildings and to occupants of single-family and multifamily residences.**
- **Consider differences in geography, building type, age, and setting (city, suburb, and rural area) and in current and possible future climate conditions.**
- **Contain specific advice on actions that will reduce the effects of climate change on the indoor environment and will improve health.**

If adverse effects of climate change are to be prevented, public education and training of professionals will be integral parts of the solution. Education and outreach to citizens—especially those in vulnerable communities—could have a large role in preventing or limiting adverse effects by making people mindful of potential problems and of the means of addressing them. The committee recommends that EPA expand its current efforts by creating and disseminating specifically tailored messages that speak to the specific circumstances and needs of the diverse audiences listed above and that are focused on steps that these audiences can take to improve indoor environmental quality in the spaces that they occupy.

**The Environmental Protection Agency should continuously evaluate actions taken in response to climate-change-induced alterations in the indoor environment to determine whether they are enhancing occupant health and productivity in a cost-effective manner, should identify initiatives that fail to achieve these objectives, and should take corrective steps as needed.**

There is little available research on how changes in climatic conditions may affect the indoor environment. It will therefore be especially important to follow up on the measures taken to lessen adverse effects to determine whether they are effective and whether there are more efficient means of achieving the desired outcomes. The committee therefore recommends that intervention programs include the collection of data that will allow evaluation of whether the programs are materially affecting the health of occupants.

**The Environmental Protection Agency should spearhead an effort across the federal government to make indoor environment and health issues an integral consideration in climate change research and action plans and, more broadly, to coordinate work on the indoor environment and health.**

The serious gap in the scientific literature concerning the relationships among climate change, IEQ, and occupant health identified in this report is a barrier to effective action on the issue. In the committee's judgment, there is a clear lack of recognition of this topic at a level commensurate with its importance.

At the US federal level, the research gap is emblematic of a more fundamental problem regarding indoor environmental health concerns: that responsibility for the integrated

environmental, public-health, energy-conservation, housing, urban-planning, and worker well-being issues that make up IEQ do not fall neatly under the aegis of any federal department or agency. Because several organizations have interests in some subjects, yet no entity has the lead responsibility, research needs go unrecognized and unmet, and opportunities for efficient action are unrealized.

The committee believes that this situation must change. Several of the priority issues listed above recommend that EPA either initiate or deepen their cooperation with governmental and other entities on some specific urgent issues and achievement of their goals will be predicated on building and sustaining robust partnerships. The committee believes that these initiatives should be part of a larger effort to entwine indoor environment and health considerations into the fabric of research and action plans. As it is difficult to separate the effects of climate change from other influences on the indoor environment, a broad approach to IEQ issues is needed.

There are several potential approaches to addressing the problem.

One is for the EPA to initiate action within the US Global Change Research Program—in which it participates—to address the effects of climate change on indoor environmental quality and on the health and productivity of occupants. The USGCRP, which involves 13 federal departments and agencies, serves as the coordinating body for federal research on climate change and its effects on society. The USGCRP is in the process of formulating a new strategic plan with the intent of releasing it in December, 2011. This process presents an opportunity for EPA to advocate for the inclusion of indoor environment and health concerns into the work of the Program and in particular, the adaptation science; assessments; and communication, education, and engagement elements of the new strategic plan.

EPA should also explore options for stimulating action on climate change, indoor environment, and health issues outside and within the government. These include the initiatives highlighted in the committee's recommendation above that the agency exercise a strong level of commitment to educate the public on these issues.

At the federal level, the committee suggests that EPA promote a broader coordinated effort to address indoor environment and health issues through, for example, the establishment of an interagency working group or a national center. Such mechanisms have been used to effectively coordinate action to identify information gaps, facilitate research, collect data, and catalyze work on other critical issues. An effort to establish a governmental entity to act as a coordinating body will likely require support from the administration or Congress. Nonetheless, the committee believes that consolidating and focusing indoor environmental health efforts may generate efficiencies that make it worthy of consideration and that any efforts that support collaboration in the pursuit of healthy indoor environments will produce societal benefits.

The United States is in the midst of a large experiment of its own making in which weatherization efforts, energy-efficiency retrofits, and other initiatives that affect the characteristics of interaction between indoor and outdoor environments are taking place and new building materials and consumer products are being introduced indoors with little consideration of how they might affect the health of occupants. Experience provides a strong basis to expect

that some of the effects will be adverse, a few profoundly so. An upfront investment in considering the consequences of these actions before they play out and thereby avoiding problems that can be anticipated would yield benefits in health and in avoiding costs of medical care, remediation, and lost productivity.

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Committee on the Effect of Climate Change  
on Indoor Air Quality and Public Health

Board on Population Health and Public Health Practice

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The serpent has been a symbol of long life, healing, and knowledge among almost all cultures and religions since the beginning of recorded history. The serpent adopted as a logotype by the Institute of Medicine is a relief carving from ancient Greece, now held by the Staatliche Museen in Berlin.

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*“Knowing is not enough; we must apply.  
Willing is not enough; we must do.”*  
—Goethe



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## Reviewers

This report has been reviewed in draft form by persons chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of the independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards of objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We thank the following for their review of the report:

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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of the report was overseen by **Richard B. Johnston**, Associate Dean for Research Development, Professor of Pediatrics, University of Colorado Denver School of Medicine, and **Lynn R. Goldman**, Dean, The George Washington University School of Public Health and Health Services. Appointed by the National Research Council and the Institute of Medicine, they were responsible for making certain that an independent examination of the report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of the report rests with the author committee and the institution.

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